Attorney Docket No: 203-032

Air Spring Strut

Cross Reference to Related Application

This application claims priority of German patent application no. 103 16 761.7, filed April 10, 2003, the entire content of which is incorporated herein by reference.

Background of the Invention

Air spring struts for motor vehicles have been known for some time in various embodiments. These air spring struts essentially include a piston element which is articulately connected at one end to an inner wheel support of the wheel suspension of the motor vehicle and is supported at the other end on the chassis of the motor vehicle via an air spring.

The air spring itself can be formed by a one-chamber system or a multi-chamber system. So-called rolling-lobe resilient members of the air spring are supported on the outer contour (wall) of a roll-off piston.

One-chamber systems are, for example, disclosed in German patent publications 3,624,296 and 4,213,676. During operation, a roll-off piston moves within the rolling-lobe resilient member of the air spring. This rolling-lobe resilient member folds over upon itself and forms the rolling lobe which, in turn, rolls off over the outer contour of the roll-off piston.

Multi-chamber systems have been proven for obtaining a highest possible spring action or damping. A two-chamber system is known from German patent publication 2,406,835 wherein the air space, which is available, is formed by two separate air chambers which, however, are connected via throttle elements such as valves.

United States patent 5,180,145 discloses a multi-chamber

system which includes an outer rolling-lobe resilient member and an inner rolling-lobe resilient member. The rolling-lobe resilient members are either directed in the same direction or are directed toward each other and roll off on roll-off pistons.

The above solutions relate to multi-chamber systems of air springs and are complex in their construction and with respect to their manufacture. In addition, these multi-chamber systems are relatively large which has been shown to be disadvantageous because of the tight conditions in the region of the wheel axles.

Furthermore, wheel contact transverse forces, which act on air spring struts, have been shown in practice to be especially disadvantageous for the support of the air spring strut as well as for the air springs thereof and these transverse forces are countered especially by the more compact configuration of the air spring struts.

A one-chamber system is suggested in German patent publication 3,624,296 for compensating the wheel contact transverse forces. In this system, the transverse forces, which counter the above-mentioned wheel contact transverse forces, are generated in such a manner that the rolling-lobe resilient member is supported on a shield. With this measure, an expansion of the rolling-lobe resilient member is countered in the direction of the transverse forces which are disadvantageous. The shield encloses the rolling-lobe flexible member in its peripheral region up to 180°, preferably, however, 90°.

This solution can bring satisfactory results for one-chamber systems. With respect to multi-chamber systems, these are built longer in comparison whereby considerably higher forces act on the air spring or its support. It is from this point that the invention proceeds.

Summary of the Invention

It is an object of the invention to provide an improved air spring strut having an air spring which is of the two-chamber system type and which is easy and cost effective to manufacture. It is a further object of the invention to provide such an improved air spring strut which has a lesser structural height than conventional air spring struts. In addition, the air spring strut of the invention exhibits a high transverse stiffness and effectively counters the disadvantageous wheel contact transverse forces.

The air spring strut of the invention is for mounting between a chassis of a motor vehicle and a wheel support of a wheel suspension. The air spring strut includes: an air spring supported on the chassis and including an outer hollow cylinder and an inner hollow cylinder disposed at least partially within the outer hollow cylinder; a piston arranged within the inner hollow cylinder and connected to the outer hollow cylinder; a first rolling-lobe resilient member arranged between the outer hollow cylinder and the inner hollow cylinder so as to seal off an outer air chamber; a second rolling-lobe resilient member arranged between the inner hollow cylinder and the piston so as to seal off an inner air chamber; the inner hollow cylinder being articulately connected to the wheel support; and, the inner air chamber and the outer air chamber being arranged eccentrically to each other.

With the above solution, an air spring strut is provided which, in an especially advantageous manner, combines a good spring action and/or damping from the multi-chamber system with an effective transverse stiffness. With the eccentric arrangement of the two air springs to each other, disturbing

wheel contact transverse forces can be countered in a defined manner whereby an improved driving performance and a longer service life results for an air spring strut configured in this manner.

A further advantage is that the air spring strut is built relatively short because of the guidance of the two hollow cylinders within each other and, accordingly, less structural space is needed than would be needed for conventional air spring struts having multi-chamber systems.

In a preferred embodiment of the air spring, the outer hollow cylinder has a lower section having openings through which struts of the inner hollow cylinder project so as to be axially moveable. In addition, it is advantageous when the piston element is connected to the lower section of the outer hollow cylinder in a region which is located between the above-mentioned openings viewed radially. With this configuration, the air spring is configured to be especially compact.

Although the openings in the lower section of the outer hollow cylinder can be virtually aligned as desired, it is preferable when these openings are arranged axially parallel to the longitudinal extension of the air spring.

In one embodiment of the invention, the two air chambers are connected to each other via bores and/or valves to permit flow therebetween in order to realize a ventilation of the air volume between the two air chambers.

Furthermore, at least one spring element is arranged on the chassis of the motor vehicle and/or on the upper end of the outer hollow cylinder and/or on the upper end of the piston element to take up impact forces or to take up the maximum force when the air spring strut bottoms. It is practical that these spring

elements are made of spring-elastic material.

Brief Description of the Drawings

The invention will now be described with reference to the drawings wherein:

FIG. 1 shows the wheel suspension of a motor vehicle having an air spring strut according to the invention; and,

FIG. 2 shows a section view of the air spring strut taken along line I-I of FIG. 1.

Description of the Preferred Embodiments of the Invention

FIG. 1 shows a wheel 15 which is supported on the chassis 5 of a motor vehicle by a wheel support 3 and an air spring strut having an air spring 1. In addition, a control link 4 is articulately connected to the wheel support 3.

The air spring 1 is configured as a two-chamber air spring wherein two hollow cylinders (8, 9) are arranged so as to be axially displaceable one into the other. The outer one of the two air spring chambers (6, 7) is defined by the inner wall of the outer hollow cylinder 8 and the outer wall of the inner hollow cylinder 9. These inner and outer walls are axially displaceably connected to each other and sealed via an elastic rolling-lobe resilient member 10.

Furthermore, the outer hollow cylinder 8 has a lower section 16 having openings 17 through which struts 18 of the inner hollow cylinder 9 are guided so as to be displaceable in the longitudinal direction. The lower section 16 is, in addition, connected to a piston element 2 which projects into the upper section of the inner hollow cylinder 9. The outer wall of this piston element 2 together with the inner wall of the upper section of the inner hollow cylinder 9 define a second, inner air chamber 7. The piston element 2 and the inner hollow cylinder 9

are connected to each other so as to be axially displaceable with respect to each other by a rolling-lobe resilient member 11 which seals the above-mentioned walls.

To ensure a ventilation of the air volumes between the outer and inner air chambers (6, 7), these chambers (6, 7) are connected to each other via bores and/or valves 12 so as to permit the flow of air therebetween.

As shown in FIG. 1, the inner hollow cylinder 9 is so arranged axially displaceable in the outer hollow cylinder 8 that the inner hollow cylinder 9 extends into the rolling-lobe flexible member 10 of the outer hollow cylinder 8 when the air spring 1 deflects. In this way, a rolling-lobe is configured with which the rolling-lobe resilient member rolls off between the wall of the outer hollow cylinder 8 and the wall of the inner hollow cylinder 9.

In the same manner, the piston element 2 extends into the rolling-lobe resilient member 11 of the inner hollow cylinder 9 whereby a rolling lobe is likewise formed with which the rolling-lobe flexible member 11 rolls off between the wall of the inner hollow cylinder 9 and the wall of the piston element 2.

The diameter d_2 of the inner hollow cylinder 9 is selected to be less than the diameter d_1 of the outer hollow cylinder 8 in such a manner that, on the one hand, the inner hollow cylinder 9 can be axially moveable in the outer hollow cylinder 8 and, on the other hand, an unhindered roll off of the rolling lobe is ensured with a correspondingly high support thereof between the two walls. The same is true between the inner hollow cylinder 9 and the piston element 2 and, for an eccentric arrangement of the two hollow cylinders (8, 9), it is important that they can move relative to each other.

A high transverse stiffness of the entire system is ensured already because of the radial support of both rolling-lobe resilient members (10, 11) in all directions. This support is significantly improved in that the two air chambers (6, 7) or the hollow cylinders (8, 9) are not arranged coaxially but are instead arranged eccentrically to each other as shown in FIG. 2.

With this measure, and as shown above, disturbing wheel-contact transverse forces can be advantageously countered in that a suitable transverse force, which counters the wheel-contact transverse force, is generated on the piston element 2.

The countering transverse force can be adjusted within defined limits by the selection of the eccentricity E shown in FIG. 2, that is, with the selection of the offset of the longitudinal axes of the two hollow cylinders (8, 9) to each other.

The piston element 2 is shown as a solid piston. However, in lieu of a solid piston, a known shock absorber can be used whereby a so-called spring damping unit is formed which, in turn, exhibits an especially favorable spring and damping characteristics.

As shown in FIG. 1, a spring element 13 is mounted on the motor vehicle chassis 5 and a spring element 14 is mounted on the piston element 2. These spring elements (13, 14) are preferably made of a spring-elastic material. Maximal impact forces or maximal forces which occur when the air spring strut bottoms can be taken up by the spring elements (13, 14).

It is understood that the foregoing description is that of the preferred embodiments of the invention and that various changes and modifications may be made thereto without departing

from the spirit and scope of the invention as defined in the appended claims.